Doc. #N1-255

Soil Moisture and Temperature Summary for Swan Lake and Tally Lake Districts

1979 Through 1983

Flathead National Forest
April, 1985

SUMMARY OF SOIL MOISTURE AND TEMPERATURE DATA

Swan Lake and Tally Lake Ranger Districts
1979 through 1983

By William J. Basko

ACKNOWLEDGEMENTS

This study was initiated by Jack Coyner and Al Martinson, Soil Scientists on the Flathead National Forest. Stations were installed in the fall of 1979 by Jack Coyner and Bob Lee, Physical Science Technician. Stations on the Swan Lake Ranger District were monitored by Les Mahugh, Steve Dagger, and Joe Yates. Stations on the Tally Lake Ranger District were monitored by Dave Miller and Ben Greeson. Moisture release curves were developed by personnel on the Kootenai National Forest.

INTRODUCTION

In the fall of 1978, a soil moisture/temperature monitoring program was initiated on the Flathead National Forest. Among the objectives for the project were:

1) To provide a basis for predicting the time of year soils are most susceptible to compaction.

2) To provide data on the yearly soil moisture status (i.e.; when soils are wet, dry, or are in transition) for possible application to fire control and silviculture.

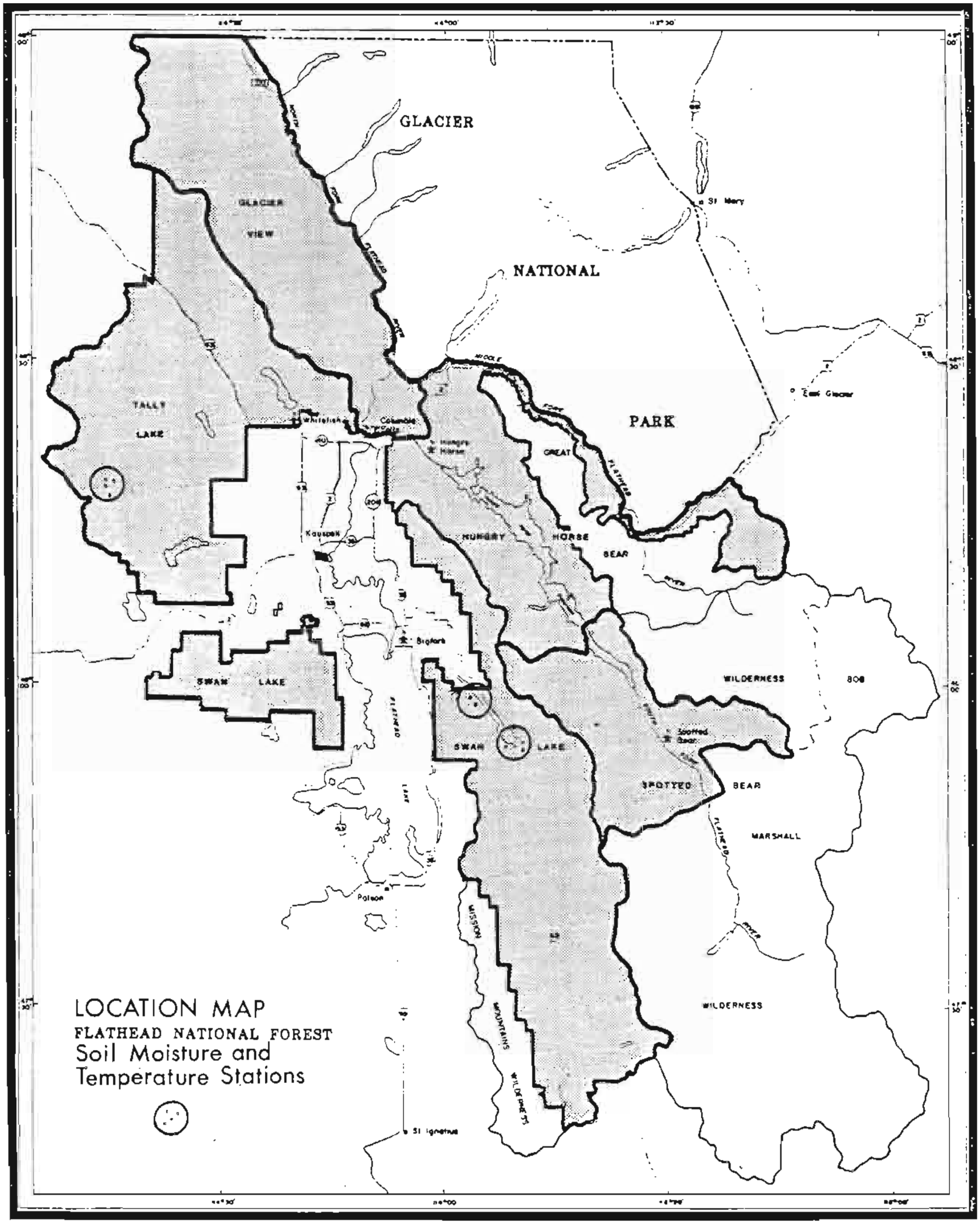
3) To obtain soil temperature data for use in silvicultural applications and soil classification, and to confirm the hypothesis that soils in this area do not freeze in winter.

4) To predict soil moisture/temperature changes as a result of management activities.

The results obtained thus far have met the first three objectives. The fourth objective will be met when sites within proposed cutting units are logged. The intent of this study was to observe general trends in soil moisture and soil temperature. The project should not be construed as research intended to undergo statistical analysis.

SITE SELECTION

To satisfy the objectives of the monitoring program, 27 stations were established on 10 sites on the Tally Lake and Swan Lake Ranger Districts. Monitoring sites met the following criteria: (1) sites had slopes less than 25%, and preferably less than 10%; (2) locations close to roads, in areas of bedrock outcrops, and close to slope breaks were avoided; (3) soils with similar characteristics were monitored (i.e.; depth to bedrock, depth of ash surface); and (4) all sites had similar aspects.


GLACIER
NATIONAL
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TALLY
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Columbia Falls
Hungry Horse
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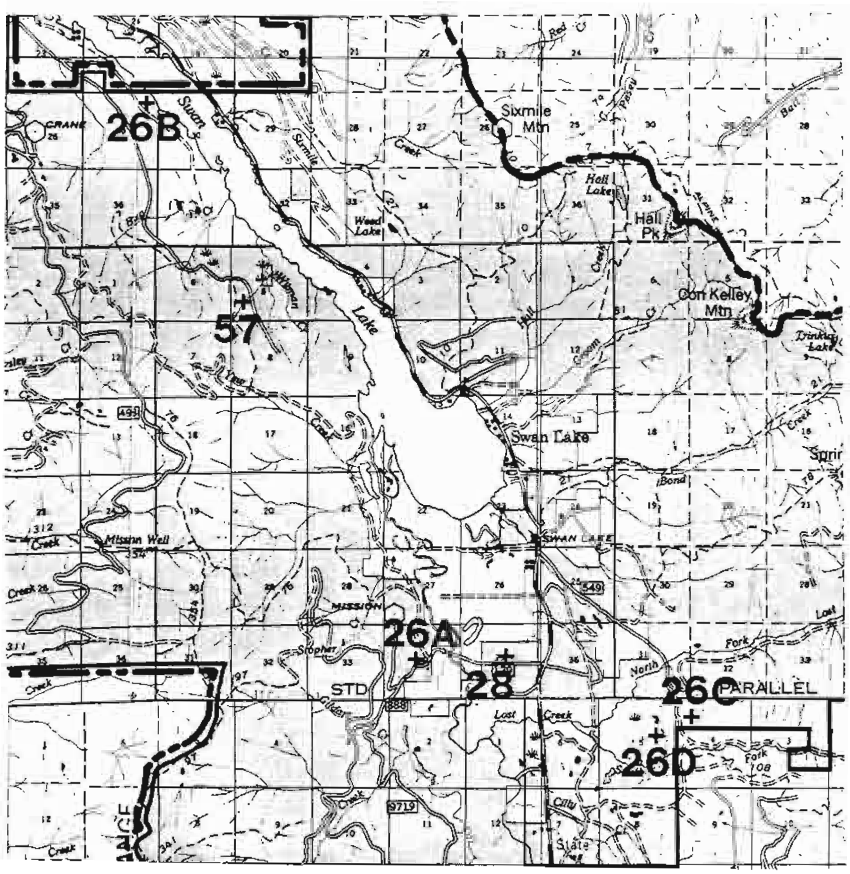
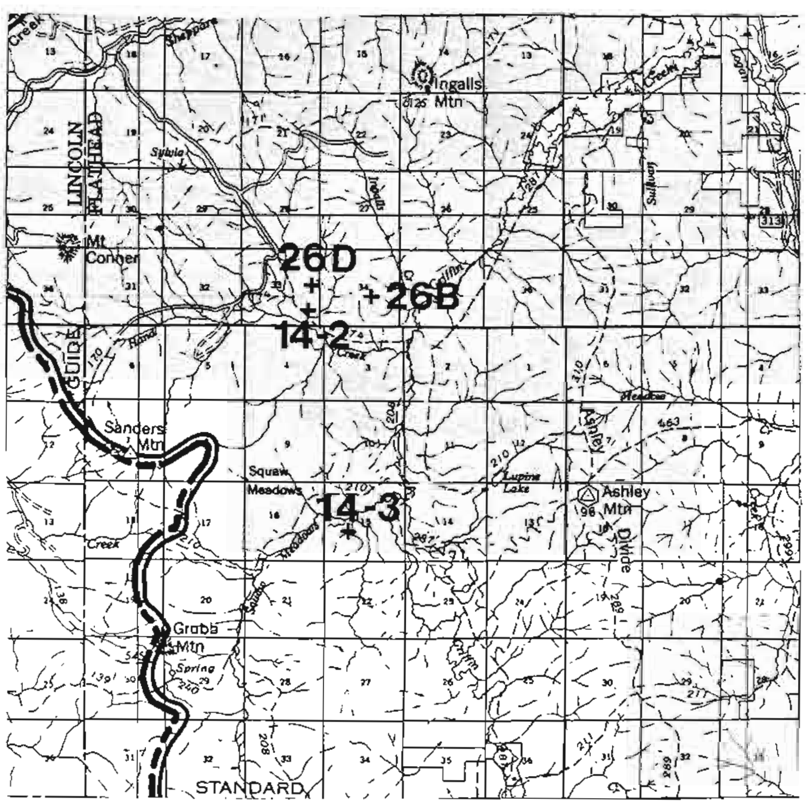
BEAR
Kalispell
Bigfork
SWAN
LAKE
SWAN
LAKE
WILDERNESS
Spotted Bear
SPOTTED
BEAR
MARSHALL
WILDERNESS
MISSION
MOUNTAINS
WILDERNESS
Polson
St Ignatius
St Mary
East Glacier
LOCATION MAP
FLATHEAD NATIONAL FOREST
Soil Moisture and
Temperature Stations

Site Location

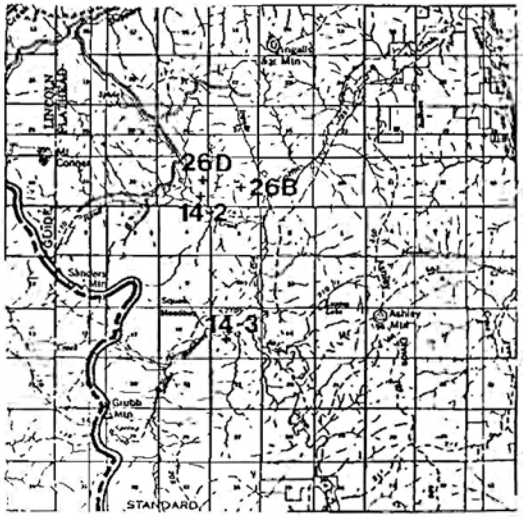


Swan Lake
Ranger District

Tally Lake
Ranger District



Tally Lake Ranger District



Swan Lake Ranger District

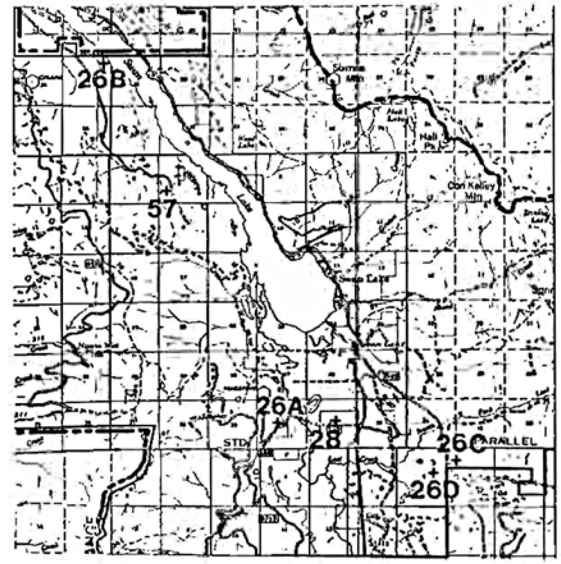


Table 1

MOISTURE - TEMPERATURE STATIONS

District	Land-type	Moisture Stations	Temp. Stations	Locations	Elev. (Feet)	% Slope	Aspect	Precip	Parent Bedrock	Soil Classification	Habitat Type
Tally Lake	14-2	3	2	S33, T30N, R25W	4400	10%	SW	25"	Undiffer-entiated	Typic Cryochrept fine-loamy, mixed	AF/Vaca
Tally Lake	14-3	3	2	S15, T29N, R25W	4500	3%	N	25"	Undiffer-entiated	Areic Halplaquent fine-loamy, mixed	AF/Vaca
Tally Lake	26-B-7	3	2	S34, T30N, R25W	4700	16%	E	25"	Piegan Argillite	Andeptic Cryoboralf loamy-skeletal, mixed	AF/Clun-Vaca
Tally Lake	26-D-7	3	2	S34, T30N, R25W	4250	15%	SE	25"	Ravalli Quartzite	Andeptic Cryoboralf loamy-skeletal, mixed	AF/Vaca
Swan Lake	26-A-7	3	3	S34, T25N, R18W	3200	8%	E	30"	Siyeh Limestone	Andeptic Paleboralf fine-loamy, mixed	WRC/Clun-Clun
Swan Lake	26-B-7	3	3	S25, T26N, R19W	3200	30%	E	30"	Piegan Argillite	Andeptic Eutroboralf loamy-skeletal, mixed	WRC/Clun-Clun
Swan Lake	26-C-7	2	2	S4, T24N, R17W	3500	15%	W	45"	Grinnel Argillite	Andeptic Eutroboralf loamy-skeletal, mixed	GF/Clun-Xete
Swan Lake	26-D-7	2	2	S5, T24N, R17W	3350	1%	---	40"	Bonner Quartzite	Andic Dystric Eutrochrept loamy-skeletal, mixed	GF/Clun-Vaca
Swan Lake	28-1	3	3	S35, T25N, R18W	3100	Flat	---	30"	Undiffer-entiated	Andic Dystric Eutrochrept sandy-skeletal, mixed	AF/Vaca
Swan Lake	57-B-7	2	2	S5, T25N, R18W	3900	10%	SW	25"	Piegan Argillite	Andic Dystric Eutrochrept loamy-skeletal, mixed	WRC/Clun-Clun

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Tally Lake District

Station on the Tally Lake District are in a 25 to 30 inch precipitation zone at elevations of 4,250 to 4,700 feet. Habitat types on these areas are indicative of cold, high elevation sites.

Swan Lake District

Stations on the Swan Lake District were selected because they typify low elevation sites that are warmer and moister than the sites on Tally Lake District. Precipitation at Swan Lake is 20 to 45 inches. Elevation ranges from 3,200 to 3,900 feet. Habitat types on these areas are indicative of warm-moist sites. Table 1 describes each site.

READINGS

During the first year, moisture and temperature readings were made at approximately 10-day intervals. After the first year, winter readings were taken less frequently for the following reasons: snow conditions hampered access and made winter readings expensive; moisture contents in winter remained relatively constant, near field capacity; and winter soil temperatures remained above freezing when there was snow on the ground. Subsequent readings were concentrated during the critical spring/summer dry-down and the fall/winter wet-up.

EQUIPMENT

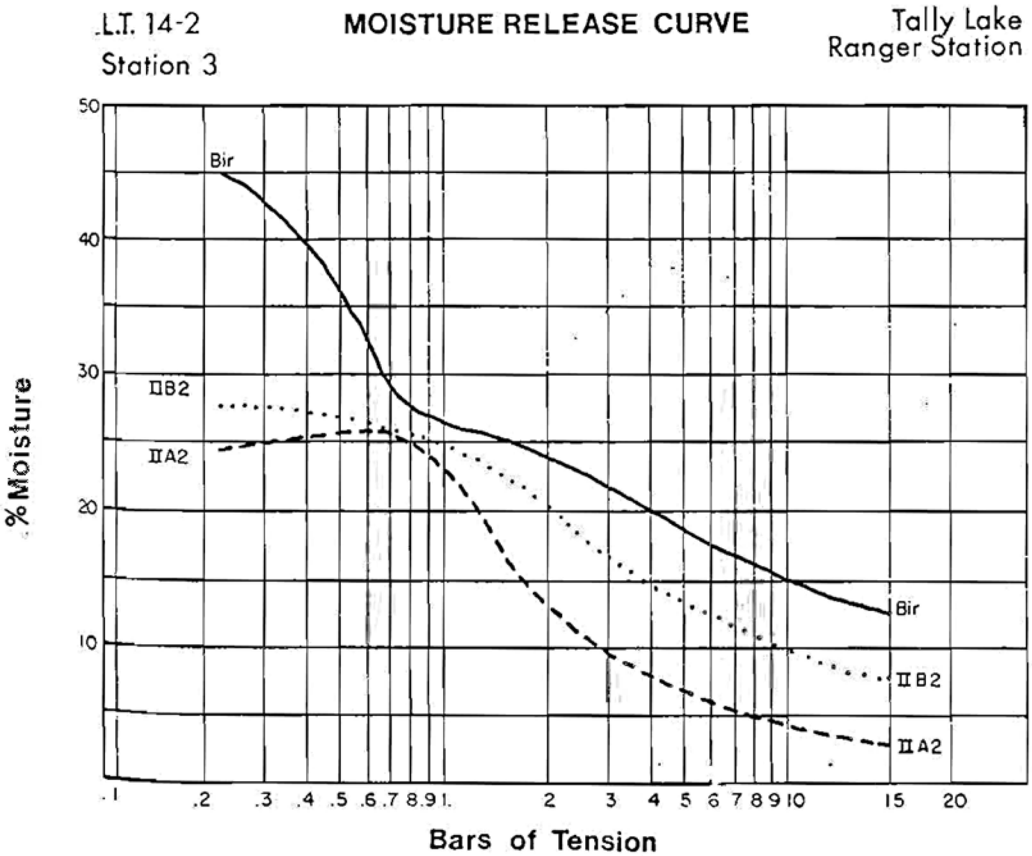
Soil moisture is monitored with Boyoucous Gypsum Blocks and a Soil Test MC-300B Soil Moisture-Temperature Meter. The selection of this equipment was based on discussions with people involved in monitoring soil climate. The consensus was that gypsum blocks give more consistent and more accurate readings than other devices available. Gypsum blocks measure electrical resistasnce, which must be converted to percent moisture. Soil temperature is monitored with fiberglass wafers that provide a direct reading of temperature in degrees Fahrenheit.

Calibration

Gypsum blocks must be calibrated to the soil they are used in. This is necessary because different soil textures produce different moisture readings for a given resistance. There are several lengthy methods for calibrating gypsum blocks. We used the simple calibration method described below.

Based on frequent observations of soil moisture trends, we determined that when soil moisture is at its highest point (close to or at field capacity) in May and June, resistance readings are approximarely 500 Ohms. When soil moistur is at its lowest point (close to or at the wilting point) in August and September, resistance readings approach 50,000 Ohms.We assumed that 500 Ohms approximates field capacity or 1/3 Bar tension, and 50,000 Ohms approximates wilting point or 15 Bars tension.

Moisture release curves were developed for each soil to determine how much water the soils contained when the moisture meter read 500 Ohms and 50,000 Ohms.



Bir	Ash Surface	0 to 6 inches
IIA2	Subsurface	6 to 12 inches
IIB2	Subsoil	12 to 18 inches

Figure 1
Moisture Release Curve for Landtype 14-2
Silty Lacustrine Soils

Moisture release curves are derived by taking a soil sample saturated with water, placing it in a "pressure chamber," and exerting a specific amount of tension or "suction" on the soil sample. At that specific tension (Bars of tension) the soil sample is removed and the percent moisture is determined. The percent moisture at various Bars of tension is plotted on a graph to give a soil moisture release curve (figure 1). Bars of tension approximate certain moisture conditions within a soil profile (i.e.; 1/3 Bar represent field capacity and 15 Bars represents the wilting point).

The perecent soil moisture at 1/3 Bar and 15 Bars tension (from the moisture release curve) was plotted on log-log graph paper at the 500 and 50,000 Ohms points respectively (Figure 2). This graph is used to convert resistance readings from the moisture meter to percent soil moisture. Each soil that was monitored has a separate graph to convert resistance to percent moisture. Results from this calibration procedure compare favorably with gravimetrically determined moisture contents of grab samples. This calibration method yields relative moisture contents that we use to show seasonal moisture trends.

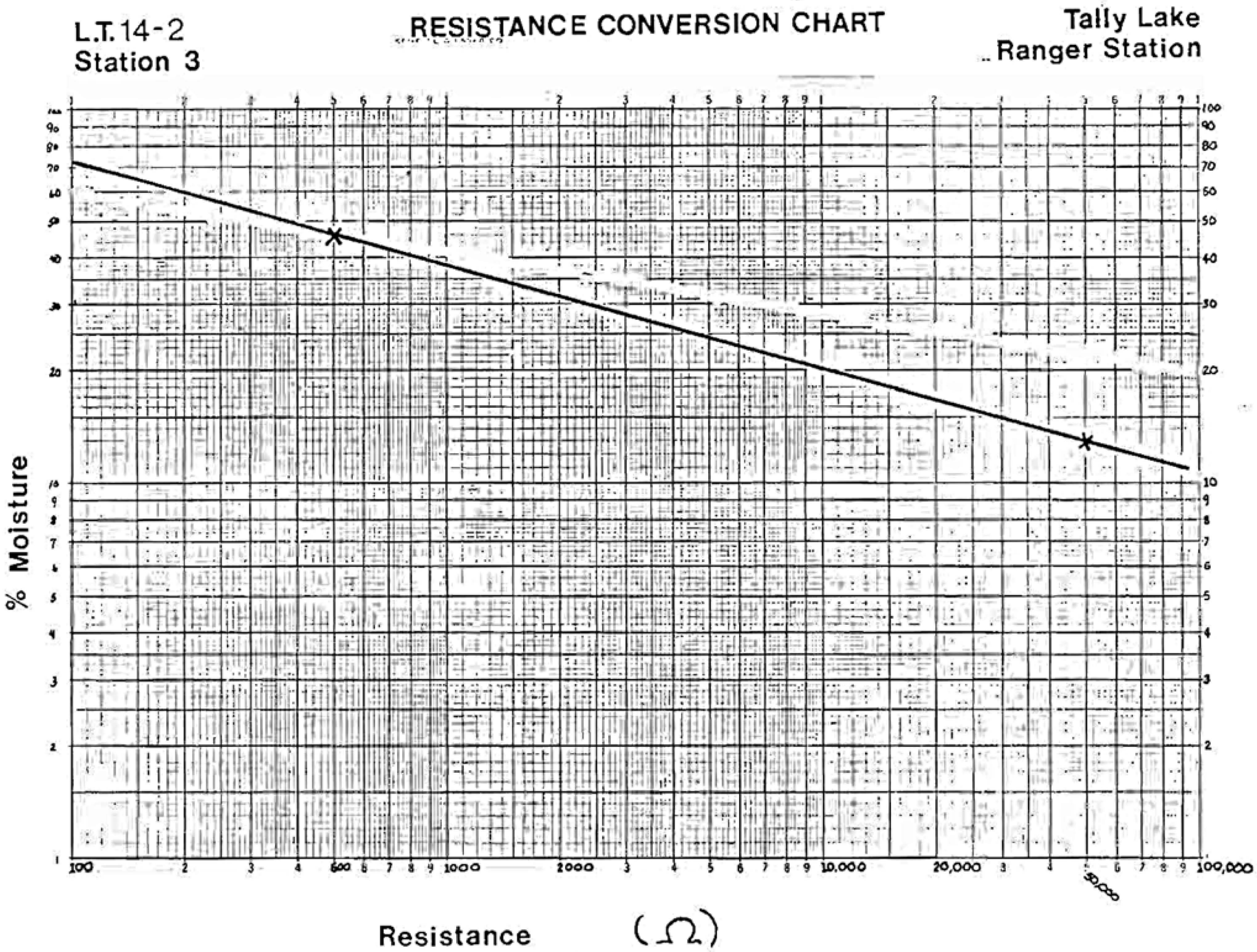


Figure 2
Chart to Convert Meter Readings in Ohms ( ) to
Percent Moisture, L.T. 14-2, Ash Surface

INSTALLATION

Gypsum blocks were buried at approximately 6, 12, and 20 inches. These depths correspond with the BIR (ash surface layer), IIA2 (subsurface), and IIB or IIC (subsoil or substratum) respectively. This placement allowed us to observe moisture gains throughout the soil profile. The fiberglass temperature monitors were buried at 20 inches, which is outside the range of soil temperature fluctuations caused by diurnal air temperature changes.

Blocks were installed in a hand-dug pit. Soil from various horizons was kept seperate. A soil description was written for each site. Blocks were immmersed in water for several minutes to achieve maximum soil contact, and were installed in small rectangular holes excavated in the uphill side of the pit. Soil was packed firmly around each block. Wires from the blocks run through and protrude from the end of PVC pipe (Figure 3). The soil was replaced and tamped to estimated original density. Station locations were plotted on a map and marked for purposes of relocation.

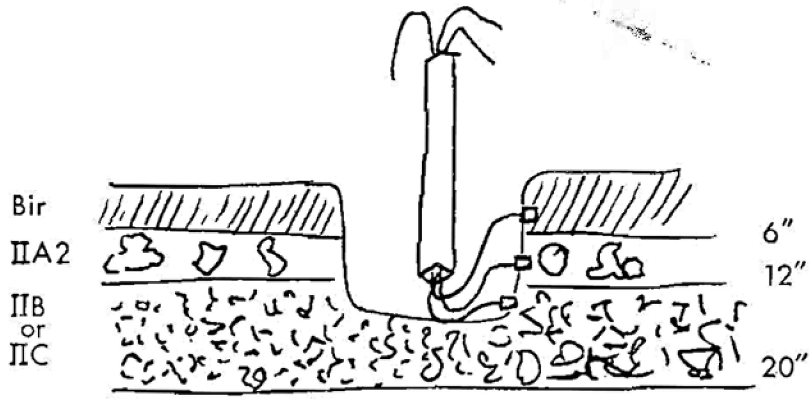


Figure 3
Moisture Blocks in a Soil Profile

SOIL MOISTURE-COMPACTION RELATIONS

Generally, moist soils are more easily compacted than similar soils that are dry. Soil scientists on the Flathead National Forest selected 4 Bars as the moisture level at which soils are dry enough to reduce the risk of compaction. Soil moisture reaches 4 Bars in August or September. Summer precipitation in the Flathead Country is seldom heavy enough to increase soil moisture once 4 Bars is reached. Fall precipitation is heavy enough to increase soil moisture contents above 4 Bars.

Wetting of Soil Horizons

Soil profiles wet up one horizon at a time. This proces has been observed in the field and is evident in our monitoring data. The organic mat that lies on the surface of most soils is the first layer to wet up. Organic matter has a high water holding capacity and can absorb considerable precipitation.

Before the ash layer, which lies below the organic mat, becomes wet the organic mat must be saturated or nearly so. In turn the ash layer which has high water holding capactiy must be saturated before the subsoil (IIA2) below wets up. This characteristic explains why considerable precipitation is required to wet soils in the fall. Summer showers often wet the organic layer without the soil below getting wet. In terms of timber management this means that summer precipitation may not restrict logging specified for dry soil conditions.

SOIL MOISTURE

General Trends

Soils have predictable wet and dry periods that are influenced by yearly precipitation patterns, landtype, aspect, and elevation. The following trends were observed on most sites.

Soils are close to or at field moisture capacity from January through May or June. Moisture content peaks in May or June. Soil moisture during this time is derived from late fall or early winter precipitaion, from constant snow melt at the snow/soil interface, and from spring snow melt. By June or early July, soil profiles begin drying. This drying trend coincides with the end of spring-summer precipitation, and increasing evapotranspiration. From August through November, and occasionally into December, soils are at their lowest moisture level. Soils are dry at this time because of a lack of precipitation and high evapotranspiration rates. Fall rains and wet snows, which usually begin between October and December, wet the soils up to field capacity (Figure 4). Trends similar to those decribed above have occured repeatedly during the monitoring program. Variations in the timing of precipitation can alter the timing of the drying and wetting trends by a few weeks. The amount of precipitaiton affects how dry or wet a soil gets. Figure 4 shows soil moisture for 1981, a dry year. This graph can be compared to the graph for 1980 in Figure 5.

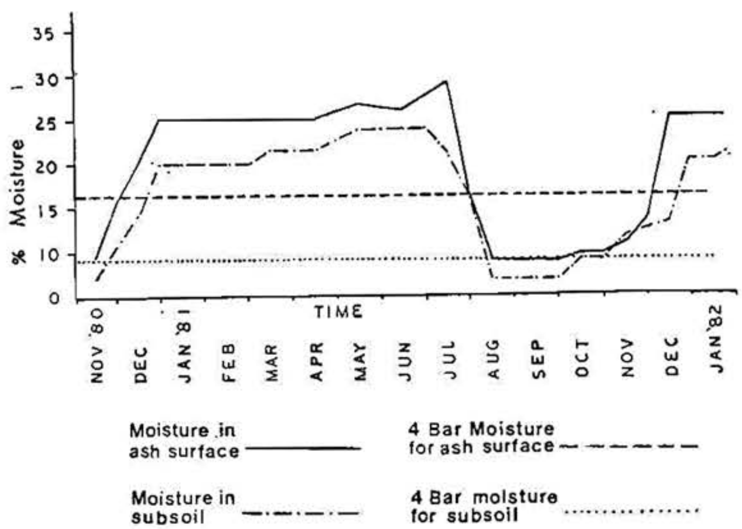


Figure 4
Landtype 26C has a silty glacial till soil with a volcanic ash surface. Low summer precipitation resulted in dry soils.

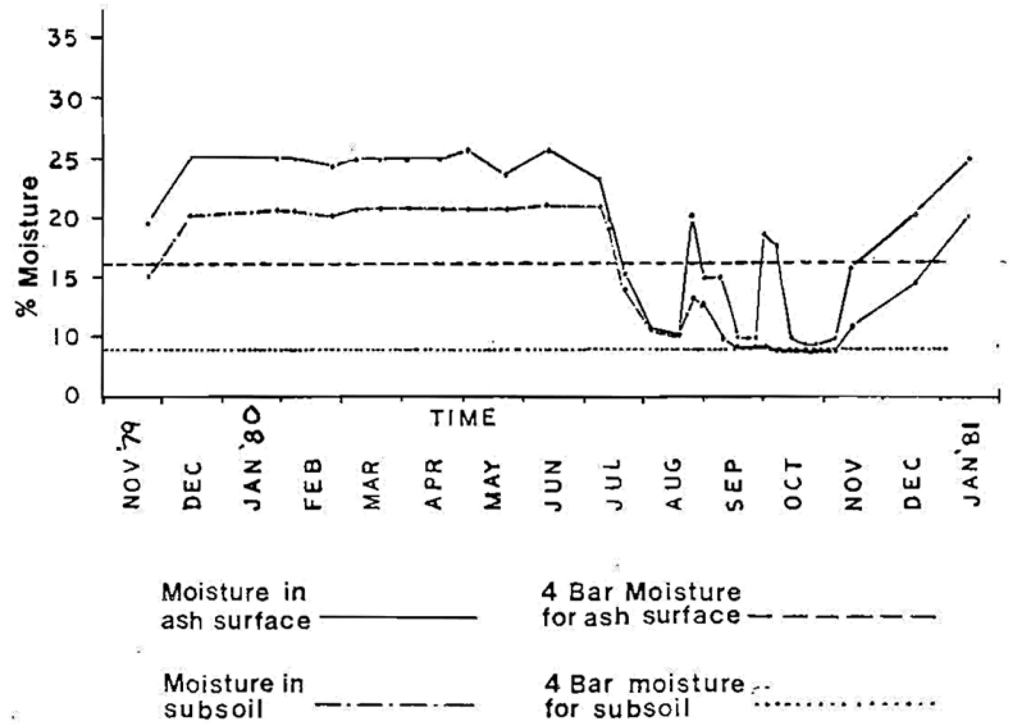


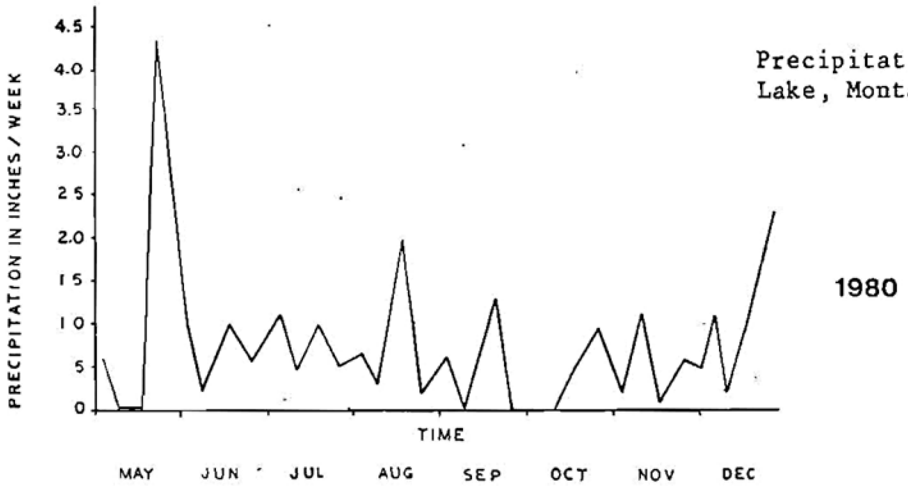
Figure 5
Soil Moisture Trend for 1980
Lantype 26C has a silty glacial till soil with a volcanic ash surface.
Frequent rains in August, September, and October kept soils moist.

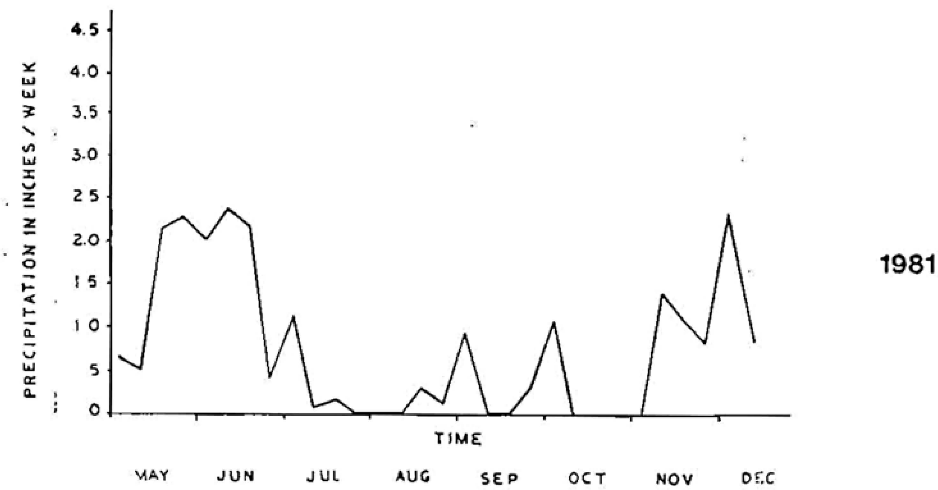
YEARLY SOIL MOISTURE TRENDS

1980

1980, the first complete year monitored, was wet. Frequent rains kept soil profiles moist during late summer and fall when soils are usually drying out. Eleven of 27 stations reached the 4 Bar moisture level. When soils are at the 4 Bar moisture content, logging tractors can operate with a reduced risk of compaction. The stations that dried to 4 Bars in 1980 were all on the Swan Lake Ranger District. Tally Lake stations showed a drying trend, but did not reach the 4 Bar moisture level. The drying trend on Tally Lake lasted from a few days to 8-weeks, with most stations dry for less than 2-weeks. In general, soil moisture fluctuated with precipitation that occurred throughout the normally dry season (Figure 6). The Tally Lake stations may have remained moist because of their higher elevation, or they may have received more precipitation than the Swan Lake stations. 1980 provided a short or nonexistent season for tractor logging on dry soils, even on Landtypes that usually dry out. Precipitation in 1980 provided adequate moisture for plant growth throughout the year.

Precipitation Data is From Swan Lake, Montana.





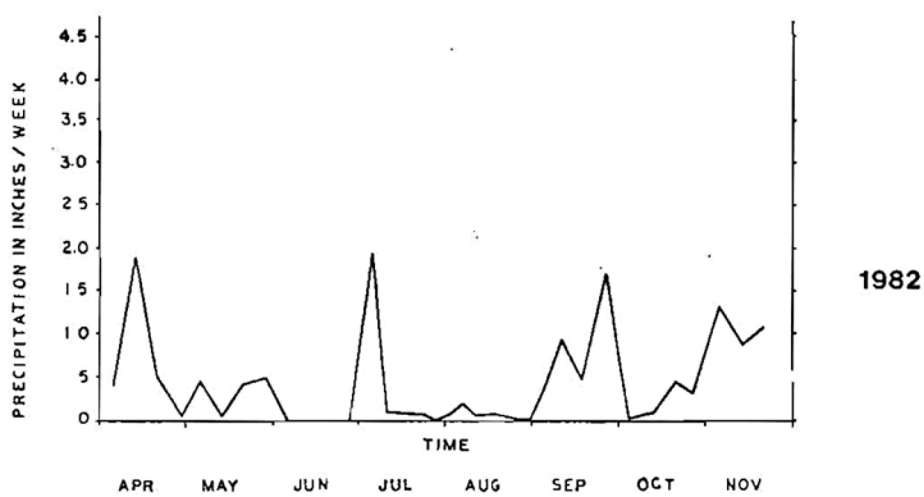


Figure 6
Weekly precipitation for May through December, 1980 and 1981, and April through November, 1982

YEARLY SOIL MOISTURE TRENDS (continued)

1981

1981 was a relatively dry year, especially when compared to 1980. All soils monitored on the Swan Lake District were dry enough to reduce the hazard of soil compaction. The safe moisture levels were first reached during late July or August, and in most cases remained dry through the last reading on December 3, 1981. Both the volcanic ash surface layer and the subsoils dried out. Some soils reached the wilting point (15 Bars) between August and November. which may have caused moisture stress for some plants. (Figure 4)

Soils on the Tally Lake District dried less and dried latter than soils on the Swan Lake District. Moisture levels reached 4 Bars in early October on a very fine sandy loam glacial till (Landtype 26D). This soil remained dry until December. Other landtypes dried out by mid-October or early November and remained dry until the last reading taken in early December. More frequent moisture readings in June July and August may have shown soil moisture was lower than indicated by the moisture curve.

1982

The discussion for 1982 pertains only to the Swan Lake Ranger Disrict. Soil moisture levels and precipitation patterns were similar in 1981 and 1982. Soils began drying 2 weeks earlier in 1982 than in 1981. This trend reflects the late spring, early summer precipitation that ended earlier in 1982 than 1981. (See Figure 6). Soil moisture levels in 1982 were similar to, or were slightly higher, than in 1981. Moisture levels of 4 Bars were reached on most stations. The dry period lasted from mid or late July through October. Moisture readings in October showed soil moisture levels to be increasing, but still safe for equipment operation. By November, soil moisture was above the 4 Bar level. Plants may have suffered water stress during July, August, September, and October on dry sites.

1983

Moisture readings in 1983, were taken less frequently than in previous years. The main objective was to see if soil moisture followed the general trends observed the previous years. A lack of readings from May 27 through July 27 precludes any definite statements about soil moisture during that time. However, weather records show precipitation was high. We assume that soils remained moist from late May through mid or late July. By late July or August rains had ceased and evapotranspiration had begun, causing soils to dry to 4 Bars. Soil moisture began increasing about the second week of November. 1983 had a dry season lasting from early August to mid-November. Plants may have been under some moisture stress. Stations on Tally Lake were moister than stations on Swan Lake. The fall wet-up on Tally Lake began in October. By mid-November, soils were at or near field capactiy (1/3 Bar). Tally Lake had a short season for logging tractors to operate with a reduced risk of compaction. However plants had adequate soil moisture during the growing season.

SOIL TEMPERATURE

Influence of Soil Temperature

Temperature is an important soil property that influences both plant growth and soil development. Seed germination requires specific soil temperatures and adequate soil moisture. Root growth, for most plants, begins when soil temperatures reach 41 degrees Fahrenheit or greater. The rate of chemical and physical processes in soils varies with soil temperature, and these processes affect soil development.

Soil temperatures were recorded with each moisture reading. Temperatures at two inches were taken with a hand-held thermometer. These temperatures approximate conditions in the rooting zone of plants. Soil temperatures at 20 inches were taken with a fiberglass wafer and a termperatur meter. We used these tempratures to classify the major soils on the Flathead National Forest.

Temperatures at Two Inches

Soil temperatures at two inches are influenced by variations in diurnal air temperatures, cloud cover, air temperature, precipitation, and ground cover. Observed temperatures at two inches have ranged from a low of 15 degrees Fahrenheit during below zero temperatures in January of 1980, to a high of 98 degrees Fahrenheit in a clearcut on July 29, 1980. Because soil temperatures near the surface fluctuate rapidly it is possible that other extreme temperatures occured but were not recorded. Normal winter temperatures at two inches range from 29 to 34 degrees Fahrenheit. Temperatures on the surface, which were not recorded probably exceeded 100 degrees Fahrenheit in clearcuts.

Temperatures at 20 Inches

Soil tempratures at 20 inches are outside the influence of diurnal air temprature changes and daily weather events. Seasonal weather changes along with ground water, surface vegetation, and snow cover affect temperatures at 20 inches. ground water has large latent heat and specific heat, which moderate fluctuations in seasonal temperatures. Wet soils are generally warmer in winter and cooler in summer than dry soils. Surface vegetation, including organic litter on the surface, insulates the soil and moderates temperatures in both winter and summer.

WINTER SOIL TEMPERATURES

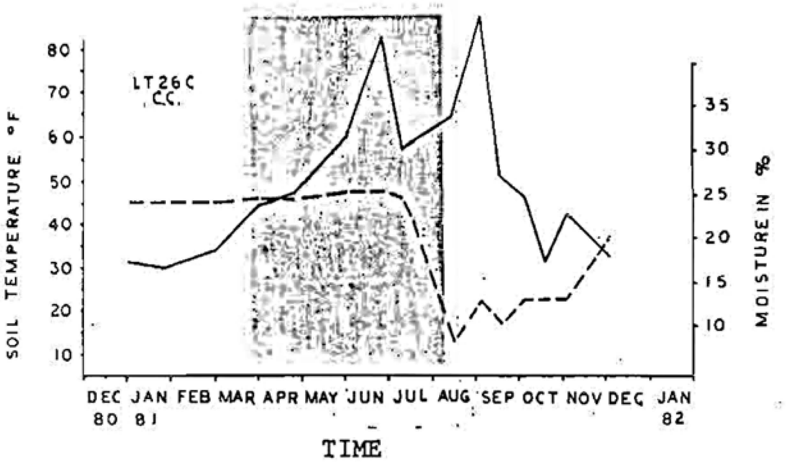
Snow greatly influences soil temperatures. In general, snow insulates the soil and moderates soil termperatures. One objective of this study was to see if soils freeze under snow.

Frozen Soils

Frozen soils are indicated by soil temperatures of 32 degrees or less, or by winter moisture readings that suddenly decrease. this sudden decrease occurs when soils freeze, and the moisture blocks no longer sense moisture. Freezing occured in January of 1979 when air temperatures reached -30 to -40 degrees Fahrenheit for about 2 weeks. Snow cover was light then and soils remained frozen for about three weeks. Periodic temperature measurements in winter have not indicated frozen soils at 20 inches since 1980. Winter soil temperatures at 20 inches usually are between 34 and 40 degrees. Soils frequently freeze down to about two inches. Frozen surface soils are sporadic in both time and extent, however they occur more frequently than at 20 inches.

TEMPERATUREAND MOISTURE REQUIREMENTS FOR PLANT GROWTH

Plants require adequate soil moisture and soil temperatures to grow and thrive. Genrally, moisture levels wetter than the wilting point (15 Bars tension) and soil temperatures above 41 degrees Fahrenheit provide adequate conditions for plant growth. On the Flathead these two conditions do not always coincide. Soil moisture is generally highest in the spring and early summer when soil temperatures have not warmed up to 41 degrees. Shortly after soil temperatures reach 41 degrees the summer dry spell starts and soils begin drying (Figure 7). Some areas have adequate moisture and temperature for a short time. The time both conditions are adequate varies with Landtype and habitat type.



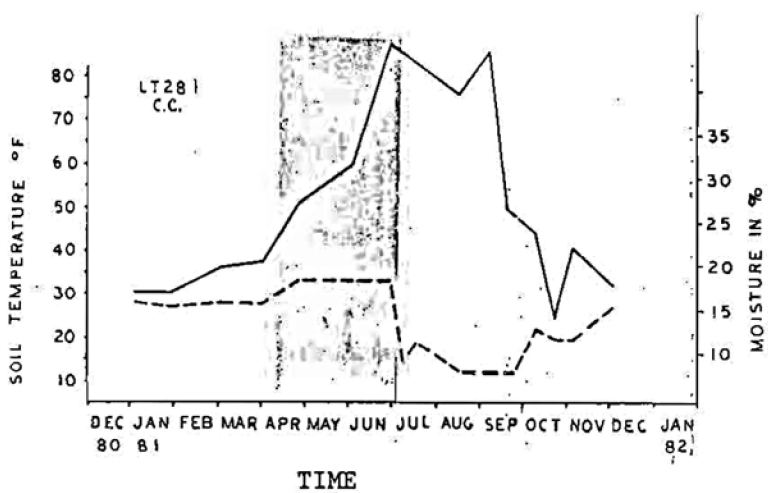
Surface ____ Temperature
Surface .... Moisture

Landtype 26C. Soils are formed in volcanic ash overlying slightly acid or neutral very gravelly loam glacial till.

Habitat Type GF/CLUN-xete.
Elevation 3500 feet
Aspesct West

Landtype 28. Soils are formed in volcanic ash overlying extreamly gravelly loam glacial outwash. The substrata is stratified sand and gravel.

Habitat Type AF/Vaca
Elevation 3100 feet
Aspect Level



Surface ____ Temperature
Surface .... Moisture

Figure 7
Shaded Area is When Both Soil Temperature and Soil Moisture are Adequare for Plant Growth.

THE EFFECT OF MANAGEMENT ON SOIL TEMPERATURE AND MOISTURE:

Monitoring stations on Swan Lake Ranger District had already undergone various management practices. Table 2 desribes the treatment each area had.

SOIL TEMPERATURES:

The highest soil temperatures recorded during monitoring were in a clear cut. Without vegetation solar radiation can reach the soil surface and heat up soils. The most dramatic temperature increases observed occur two inches below the surface where temperatures were commonly 25 to 30 degrees greater in clear cuts than in forested sites. Temperature increases also occur in the subsoil. For example, temperatures at 20 inches on Landtype 28-1 were 9 or 10 degrees higher in the clear cut than in the undisturbed forest. Temperatures on the surface were not recorded, but are highest in clearcuts where they often exceed 100 degrees Fahrenheit.

SOIL MOISTURE:

After trees are harvested soil moisture increases. Areas that usually dry out may remain moist. This is probably because there is not enough vegetation to use water stored in the soil profile. When vegetation returns to the area and begins using soil moisture soils again dry out during the summer and fall.

Table 2

Management Situation on Monitoring Sites

District	Landtype	Number of Stations	Station Number and Management Situation
Tally Lake	14-2	3	all forested
Tally Lake	14-3	3	all forested
Tally Lake	26C-7	3	all forested
Tally Lake	26D-7	3	all forested
Swan Lake	26A-7	3	1 thinned 2 forested 3 forested
Swan Lake	26C-7	3	1 forested 2 forested 3 forested
Swan Lake	26C-7	2	1 clearcut 2 thinned
Swan Lake	26D-7	2	1 clearcut 2 undisturbed
Swan Lake	28-1	3	1 undisturbed 2 undisturbed 3 clearcut
Swan Lake	57-7	2	1 undisturbed 2 clearcut

CONCLUSION

Temperature and moisture are important soil properties. They control soil development and plant growth. Soil moisture influences the amount of soil compaction resulting from management activities. Monitoring soil temperatures and moisture has enabled soil scientists on the Flathead National Forest to do the following: determine when soils are most susceptible to compaction; predict when and if specific landtypes will dry out; accuretly classify soils; determine that soils seldom freeze in winter when there is a good cover of snow; predict changes in soil temperature and moisture as a result of management activities. When units that have been monitored since 1979 on Tally Lake District are logged, better conclusions may be drawn about the effects of management on soil climate.

USE OF MOISTURE AND TEMPERATURE TRENDS

The general soil moisture trends for Swan Lake and Tally Lake Districts depicted in this report are repeatd throughout the forest. However, when extrapolating these concepts to other areas be aware of precipitation zones, Habitat types and Landtypes. These factors can affect soil moisture and temperature. Perhaps the factor with the greatest affect is precipitation. Unfortunatly precipitation in this area is variable from year to year. In years with high precipitation soils will dry later in summer and will not become as dry as in year with low precipitation.

SUPPORTING INFORMATION

Supporting information, including complete temperature and moisture data collected on all sites, is available on request from soil scientists at the Flathead National Forest Supervisor's Office in Kalispell, Montana. Soil moisture release curves are available for each soil that was monitored. Appendix A contains an example of the supporting information available for each station.

Appendix A

Soil Moisture and Temperature Data for Tally Lake Ranger District

LANDTYPE: LT 14-2

LOCATION: Sec 33, T,30N.,R25.W.

HABITAT TYPE: ABLA/VACA

MEAN ANNUAL PRECIPITATION: 25"

ELEVATION: 4400'

ASPECT: S.W. SLOPE: 10%

MOISTURE REGIME: Udic

TEMPERATURE REGIME: Cryic

SOIL CLASSIFICATION: Typic Cryochrept, fine-loamy, mixed.

MANAGEMENT SITUATION:
- Station 1: forested
- Station 2: forested
- Station 3: forested

MOISTURE CONTENT BY HORIZONS:

	1/3 Bar	4Bars	15Bars
Bir	45%	20%	15%
IIA2	24%	8%.	3%
IIB2	27%	15%	8%

Soil Description

01/02 5-0 centimeters. Organic duff.

A2 0-3 centimeters. Light gray (10 YR 7/2) moist crushed color; silt loam; weak, fine, sub-angular blocky structure; soft, dry consistence; very friable (moist), non-sticky, non-plastic (wet); 5% coarse fragments by volume; pH 5.0; many, fine, medium and coarse roots; clear wavy boundary.

Bir 3-14 centimeters. Dark yellowish brown (10 YR 4/4) moist crushed color; silt loam; weak, fine, sub-angular blocky structure; soft, dry consistence; very friable (moist), non-sticky, non-plastic (wet); 5% fragments by volume; pH 6.3; many, fine; medium and coarse roots; clear wavy boundary.

IIA2 14-24 centimeters. Light brownish gray (2.5 YR 6/2) moist crushed color; silt loam; weak, medium, sub-angular blocky structure; slightly hard, dry consistence; friable (moist); mon-sticky, non-plastic (wet); 5% coarse fragments by volume; pH 6.4; common, fine and medium roots; clear wavy boundary.

IIB+A 24-66 centimeters. Light yellowish brown (2.5 YR 6/4) moist crushed color; silt loam plus; weak, medium, sub-angular blocky structure; slightly hard, dry consistence; friable (moist), slightly sticky, non-plastic (wet); 5% coarse fragments by volume; pH 6.5; few fine roots; clear wavy boundary.

IIB2 66-85 plus centimeters. Light olive brown (2.5 YR 5/4) moist crushed color; silt loam plus; weak, medium, sub-angular blocky structure; slightly hard, dry consistence; friable (moist), non-sticky, non-plastic (wet); 5% coarse fragments by volume; pH 7.0.

See page 117 and 118 of the Flathead Country Land System Inventory for laboratory data and range of characteristics for soils in landtype 14-2. See page 159 for the distribution of landtypes by Ranger Districts

PRECIPITATION SUMMARY

Daily weather data for this area is available at the Flathead National Forest Supervisor's Office in Kalispell, Montana. Weather data is from two sources. Data from January, 1979 through September, 1981 is from the weather station five miles northwest of Whitefish, Montana. This station is east of Whitefish Lake at the base of Big Mountain. Elevation is 3060 feet above mean sea level. This weather information is contained in the Climatological Data Summary for Montana published by the National Oceanic and Atmospheric Administration. Phyllis Snow, forest hydrologist has this information. Data from October, 1981 through October, 1984 is from a forest service precipitation gauge located at Squaw Meadows on the Tally Lake Ranger District. The elevation of this station is 5400 feet above mean sea level. Precipitation at these two stations compare fairly well. Wallace Page, forest hydrologist, has this information.

A summary of monthly precipitation in inches.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1979	1.48	2.30	1.27	1.94	2.08	1.58	1.29	1.76	.32	1.82	.55	2.61	19.00
1980	2.24	1.95	1.77	1.92	5.90	3.37	1.24	1.85	1.24	.40	2.00	4.30	28.18
1981	1.80	2.60	2.08	1.86	4.26	5.57	1.63	.35	.96	.98*	1.48*	3.51*	27.08*
1982	1.64*	3.66*	3.26*	2.64*	1.71*	3.54*	1.63*	.93*	1.79*	1.18*	2.05*	2.41*	26.44*
1983	3.12*	1.20*	2.40*	2.55*	1.33*	3.79*	3.08*	1.30*	1.05*	.99*	2.43*	2.20*	25.44*
1984	1.64*	1.12*	2.05*	2.99*	2.65*	3.52*	.25*	.74*	1.96*	3.03*			

* Precipitation data from Squaw Meadows.

Summary of Station Data:

1979 Insufficient data.
1980 All stations began drying in early August, however the stations did not reach 4 Bars moisture. Moisture content fluctuated between 4 Bars and 1/3 Bar.
1981 All stations began drying in mid-August. Our data does not indicate if 4 Bars was reached.
1982 In early September stations were wetter than 4 Bars moisture.
1983 Stations did not reach 4 Bars moisture.

Readings for all Stations on Landtype 14-2
Upper temperature is at 2 inches, bottom temperature is at 20 inches

Surface temperature was taken with a hand probe. Temperature at 20 inches was taken with a thermistor and a soil test moisture-temperature meter. Moisture was measured with a gypsum block and a soil test moisture-temperature meter.

		11/01/79		11/14/79		11/30/79		12/11/79		12/20/79		01/07/80	
Station	Horizon	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp
	Bir	30		29		26	28	34		34	32	32	34
1	IIA2	5		6		6		11		13.5		13	
	IIB2	10.5		12		12		15		20		19.5	
	Bir	26		23.5		15	25	37		33	32	30	38
2	IIA2	6		5		4		9		10		9.5	
	IIB2	10.5	40	10	39	10	36	13	36	16	35	18	34
	Bir	31		28		10	27	32.5		31	32	31	34
3	IIA2	4.5		9.5		8		8		10.5		12.5	
	IIB2	13.5	39	12		11	35	11	35	13	35	17	34

		01/22/80		02/05/80		02/26/80		04/16/80		05/02/80		05/15/80	
Station	Horizon	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp
	Bir	34	34	31	31	32	32	41	34	41	38	42	39
1	IIA2	14		12		13		20		21		22	
	IIB2	21		19.5		20		27		28		29	
	Bir	31	32	15	31	25	32	24	32	41	36	42	37
2	IIA2	15		6		6.5		14		21		22	
	IIB2	18	34	13	34	14	33	21	34	28	34	29	38
	Bir	32	32	24	31	32.5	32	41		41	39	42	39
3	IIA2	13.5		12		12.5		18		19		20	
	IIB2	18	34	16	34	17	34	27	34	30	34	30	38

		06/04/80		06/30/80		07/18/80		08/06/80		08/27/80		09/10/80	
Station	Horizon	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp	%H2O	Temp
	Bir	42	39	42	48	42	50	40	48	35	50	36	
1	IIA2	23		23		24		21		16		16	
	IIB2	29		30		31		30		25		25	
	Bir	42	37	42	48	42	50	39	48	32	50	31	50
2	IIA2	23		23		24		18		12		11	
	IIB2	29	40	31	44	31	46	29	48	22	48	22	48
	Bir	42	37	43	48	43	50	41	48	39	50	39	47
3	IIA2	21		22		23		22		20		20	
	IIB2	31	39	31	44	33	46	30	46	28	46	26	42